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STATUS REPORT ON EVALUATION OF SOLID WASTE DISPOSAL AT ORNL: I

K. E. Cowser
T. F. Lomenick
W. M. McMaster

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By

K. E. Cowser, T. F. Lomenick, and W. M. McMaster*

Summary

The criteria employed in selecting a site for disposal of solid wastes, the methods used in evaluating a site, and preliminary analysis of a new burial trench design are discussed.

Forty-five auger wells were drilled to determine the character of the residual cover, the depth of the water table, and the chemical and radionuclide composition of the ground water. A descriptive geologic map and depth-to-water and water-table contour maps were prepared. Five deep wells were drilled to determine the occurrence and circulation of ground water at greater depth in the burial area. Pressure tests of the deep wells showed that the most permeable zones or fractures occur within the first 100 ft. Hydrographs for the deep wells showed a maximum water-level fluctuation of 14 ft and a minimum fluctuation of 1.5 ft over a period of approximately 8 months.

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*Geologist, U. S. Geological Survey - The work on geologic characteristics included in this report is a part of the co-operative program of the U. S. Geological Survey.

To estimate the requirements of land usage through 1964, records of solid waste burial dating back to 1957 were analyzed. By linear extrapolation of the data, it is estimated that an additional 2.0 x 10^6 cu ft of solid waste will be buried at ORNL through 1964. Using depth-to-water maps and restricting the depth of burial to 1 ft above the highest water level, it was determined that approximately 21 x 10^6 ft^3 of volume is available for disposal of solid waste. Although only one-third of this volume will be occupied by solid waste, the eastern one-half of the new burial ground should provide ample burial space through 1964 at the anticipated load.

To improve operations and monitoring, a new trench design is recommended. The bottom of the trench, covered with 6 in. of gravel, is sloped to an asphalt-lined sump at one end in which a 6-in. perforated casing is installed. Any liquid entering the trench will flow primarily through the gravel underdrain to the collecting sump, whence samples can be withdrawn and analyzed. To date two trenches have been completed. In one trench waste containers were placed upright in the trench, while in the other they were simply dumped into the trench. Beta, gamma, and alpha activity was detected in water samples taken from the sumps at the end of each trench. Monitoring data to date indicate that damage to the containers does not cause an increase in the activity leached. The additional cost of the sump, well, gravel underdrain, and asphalt cover was $0.02 per ft^3 of trench space. The cost of protecting the drum by careful placement in the trench was $0.07 per ft^3 of trench space.

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Introduction

At the Oak Ridge National Laboratory solid waste contaminated with radioactive materials is disposed of by land burial. Five sites have been employed since the beginning of operations. The first three, now abandoned, were located without prior geologic and hydrologic explorations. Originally, little emphasis was placed on site evaluation due to the relatively small amount of waste handled. However, as the volume of waste at Oak Ridge increased and the quantity and variety of solids from off-site agencies expanded, greater consideration was given to the selection of sites for burial grounds. In a report by Stockdale[1] it was pointed out that the preferred place for disposal of radioactive waste in the vicinity of Oak Ridge would be in an area underlain by the Conasauga shale formation. Burial Ground 4 and the area considered in this report, Burial Ground 5, are situated in this geologic formation.

As a result of yearly increases in the volume of solid waste buried, the 25-acre site (Burial Ground 4) was filled rapidly. Additional off-site shippers, more frequent off-site shipments, and greater local demands, increased the requirements for land from about 1.5 to 5.0 acres per year.[2] Off-site shipments used up about 50% of the area.

Frequent accounts have appeared in the literature[3, 4, 5] describing the methods used in land burial of solid waste contaminated with fission products, but little information is available on the effectiveness of such burials. Disposal of municipal refuse by the sanitary land-fill method established a precedent for land burial, and from such operations general knowledge was obtained that soils act as a sorbent for certain materials. Soils are now used extensively by the atomic energy industry for disposal of both liquid and solid waste.[6, 7, 8]

There is a lack of pertinent information to decide if the present practice of solid-waste disposal at ORNL is both safe and economical. Information is needed on the leachability of radionuclides from various types of solid waste under field conditions, on the rate and extent of underground movement of radionuclides, and on the geologic and hydrologic characteristics of the site to evaluate present practices and to suggest changes in the operation that might be beneficial.

Experience at ORNL in the disposal of liquid waste to surface pits indicated the lack of uniformity of Conasauga shale and emphasized the need for site evaluation.[7, 9] Because of the complexity of the environment and the differences in solid and liquid wastes, it was impossible to extrapolate from studies of liquid-waste disposal in pits to the expected operation of a solid-waste burial ground. Therefore, a preoperations study of a new site for solid-waste burial was instigated; and, concurrently, investigation of Burial Ground 4 began.

This report includes a discussion of criteria employed in selecting a site for the burial of solid waste, the methods used in evaluating a site, an appraisal of experience in solid-waste burial, the preliminary analysis of a new burial trench design, and conclusions relative to improvements expected in the new burial ground.

Considerations of Site Selection[10, 11]

General Requirements

A minimum number of burial grounds is desirable to reduce the costs of site investigation, monitoring, and relocation of facilities and equipment. Small scattered burial grounds increase the problems of management as well as monitoring.

The size of the new ORNL burial site had to be ample to meet the needs for the next 4 to 5 years. Land usage at the rate of 5 acres per year was the basis for determining the area required.

A burial site should be an area of gentle relief for ease of operation and yet not be subject to flooding by surface water or a high ground water table. With a sufficient depth to ground water, contaminated solids can be suspended above the ground water table to prevent leaching. Excessive soil erosion by surface runoff is undesirable. Other features of a burial site include a soil that is easily excavated by earth-moving equipment and yet firm enough to stand in steep cuts, a short hauling distance, and private roads for hauling.

Of the four primary geologic formations available in Oak Ridge, Conasauga shale is the most desirable for waste disposal, based on its hydrologic, geologic, and geochemical characteristics. The reasons for this are enumerated elsewhere.[1, 12] While the same formations are repeated several times in the Oak Ridge Reservation by the intervention of many thrust faults, the Conasauga shale underlying Melton Valley is most convenient to the Laboratory. Waste-disposal operations are presently conducted in this area.

Although Melton Valley was selected as the general area for location of a new burial ground, other interests in land usage were also considered. These included the unique ecological research opportunity afforded by the Melton Valley environment,[13] the location of future reactors, and the location of future waste pits. Furthermore, it was desirable to limit the selection of a new site to the White Oak Lake drainage basin. Burial operations in this drainage basin take advantage of the existing stream gaging and sampling station that monitor the collected drainage before it leaves the controlled area.

Field Survey

Four areas were selected by the use of Fig. 1, Topographic Map of Melton Valley, for a preliminary field survey. A reconnaissance of these areas was made.

Area A was believed to be the most suitable for a new burial ground. About 20 to 25 acres of gently to moderately sloping land is included within this area, although the relief immediately east of the section is probably too great for convenient operations. The site is within 1 mile of the Laboratory, is located in the White Oak Lake drainage basin, and may be entered conveniently by an extension of existing roads. The depth to ground water in this section was believed to be great enough for suitable operation.

Area B could be used for burial, but there are certain characteristics that make it suitable as a seepage-pit site for the disposal of liquid wastes. The topography and anticipated depth to ground water meet the requirements

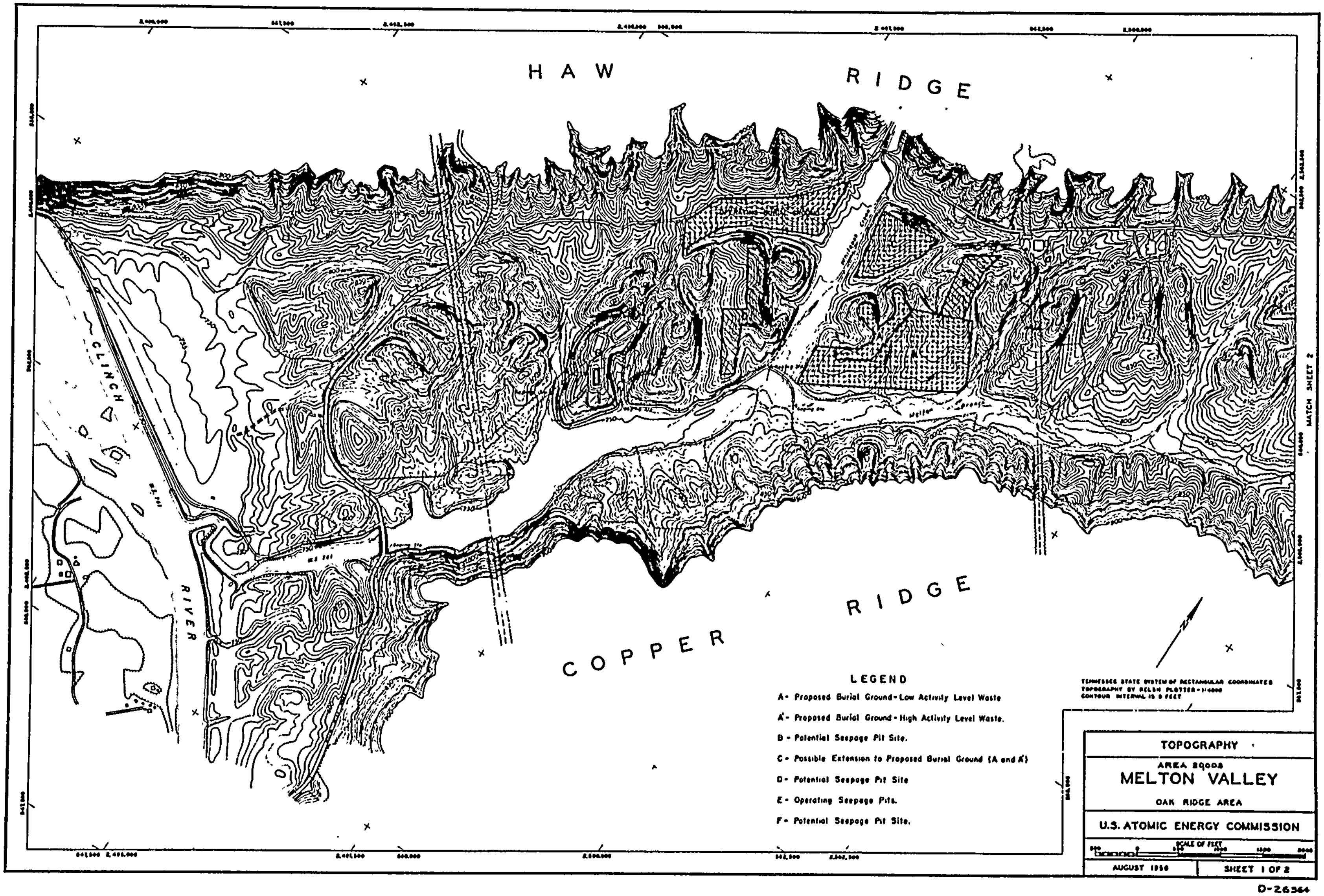

Fig. 1. Topographic Map of Melton Valley.

of seepage-pit disposal.[12] Further, the site is located near an established road and power line and relatively close to the existing pipeline used to convey liquid wastes to the present pits.

Area C could be used as an extension of burial operations in Area A. However, the size of this section is limited to about 5 acres, and does not meet the primary requirement of a burial capacity for the 4- to 5-year period.

Area D was found to be divided into sections smaller than indicated on the topographic map by natural surface drainage cuts, several of which were of considerable relief. The total area of this section is small, and development and operation costs would be greater than in Area A. Nevertheless, the extended ridge of this area appears to be suitable for seepage-pit operation and offers the advantage of locating new pits close to the existing system.

Evaluation of the meteorological conditions in the Oak Ridge area, including the Melton Valley environment,[14] and climatological observations that are presently taken on the bed of former White Oak Lake,[15] will furnish the necessary information to assess problems of atmospheric contamination that may be associated with operation of the burial ground.

Geologic and Hydrologic Conditions

Area A of Fig. 1 was selected for development as a burial ground. It is the largest tract of land near the Laboratory within the White Oak Creek drainage basin that will not interfere with other operations or facilities.

Geologic Characteristics

The site is situated on the line of knobs underlain by more silty layers along the northwest side of Melton Valley. The topography is that typically developed on shale, with numerous steep-sided gullies, some of which are more than 10 ft deep. Within the site, elevations range from 765 to 875 ft, a maximum relief of 110 ft.

The principal types of rock of the site are shale, siltstone, and limestone. There is no obvious distinction across the strike due to the gradational nature of the rock.

In the lower elevations northwest of the site the area is underlain by fairly pure multicolored shale. Siltstone and lenticular shaly limestone are present in minor amounts.

The amount of limestone and siltstone increases from northwest to southeast (see Fig. 2). Some of the siltstones are spongy and friable and represent layers of silty limestone from which the calcium carbonate has been leached. In places limestone can be seen to grade laterally into siltstone. The siltstone layers are interbedded with thin shales, most of which are olive green, with stained joint surfaces. The siltstone layers have well-developed joints which are usually open near the surface. Ground-water circulation in these layers is probably greater than in less silty layers where the joint surfaces are not so widely spread.

The weathered zone is thicker on the top of the knobs than at lower elevations. In areas of higher elevation, weathered shale is found at depths up to 35 to 40 ft; whereas in low topography, fresh rock is found within a few feet of the surface.

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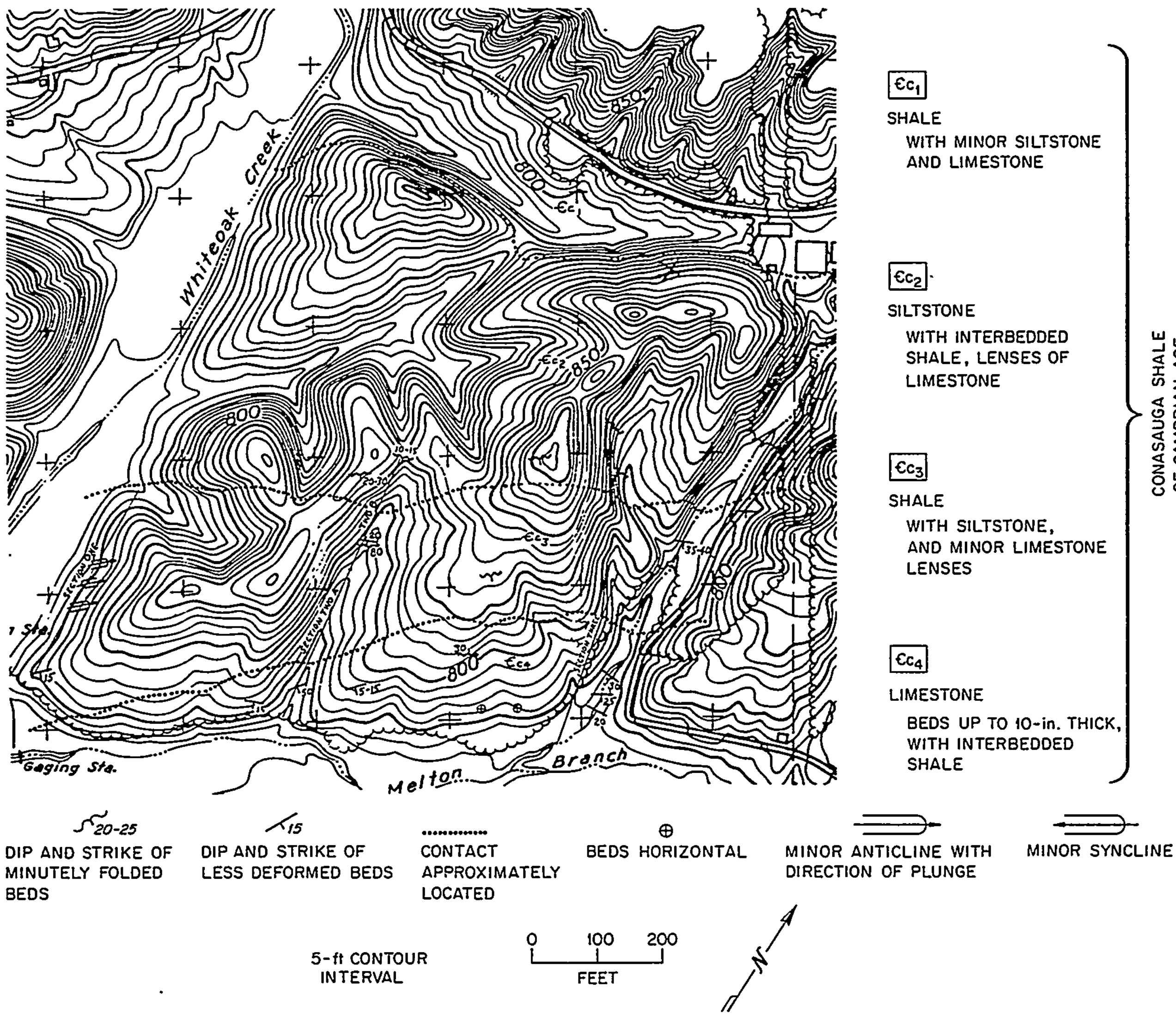

Fig. 2. Geologic Map of New Solid-Waste Burial Ground.

The rock grades on the southeast into silty shale with thin layers of siltstone. The shale shows well-developed joints which are more closely spaced and tighter than those in the siltstones. Thin, lenticular beds of limestone appear and are interbedded with shale as the silt decreases to the southeast.

The southeasternmost zone contains limestone with interbedded shale. The limestone is mostly medium-to-dark gray, dense to crystalline, with irregular bedding planes; beds are up to 10 in. thick. Outcrops are relatively common in streams flowing across the strike. The lithology appears to be continuous along the strike.

The Conasauga shale is a structurally incompetent unit lying between the competent Rome formation and the Knox group. During deformation of the region, the shales, siltstones, and thin limestones were badly deformed. The beds generally dip to the southeast at a low angle, but many small structures and variations of dip and strike are present. Small anticlines and synclines are common. The thinly bedded, less silty shales are usually the most deformed of the lithologies.

Several small faults may be present which would have an influence on ground-water circulation, but evidence was insufficient to define their location.

Hydrologic Characteristics

Auger wells, relatively shallow borings cased with perforated pipes surrounded by gravel, are used where the depth to water does not exceed 15 to 20 ft. Samples collected from such wells represent the liquid in the weathered zone, which is the important zone of flow in Conasauga shale. Their chief disadvantages are the limited depth of penetration and the occasional sluggish response to a change in water level. Forty-five auger wells, ranging in depth from 5 to 21 ft, were completed in Area A, and water-level measurements were made about once a week, from May 1958 through September 1959.

Although most of the auger wells located above a ground elevation of 800 ft were dry the greater part of the year, water-level contours were developed from measurements taken during wet periods of the year. Figure 3 shows the depth-to-water contours for the period from May 1958 through June 1959. In general, the values used to construct these contours were the minimum values observed for the 14-month period. The areas immediately adjacent to wells 144, 154, and 162 are believed to be subject to limited perched water conditions during periods of heavy rainfall. However, the rate of water-level decline following periods of recharge was rapid, averaging about 0.3 ft per day.

In order to define further the hydrology of the site, five 150-ft-deep wells were drilled. Hydrographs (weekly water-level elevations with time) were made of the wells to determine water-table fluctuations. As shown in Fig. 4, the water level in all wells rises during the wet winter months and falls during the summer months when evaporation and transpiration are greater and rainfall is less. However, there is a wide range in water-level fluctuations between the wells. The maximum fluctuation observed from October 1959 to May 1960 was 14 ft in well 176, while the minimum change of 1.5 ft occurred in well 177 in the same period. The reasons for these

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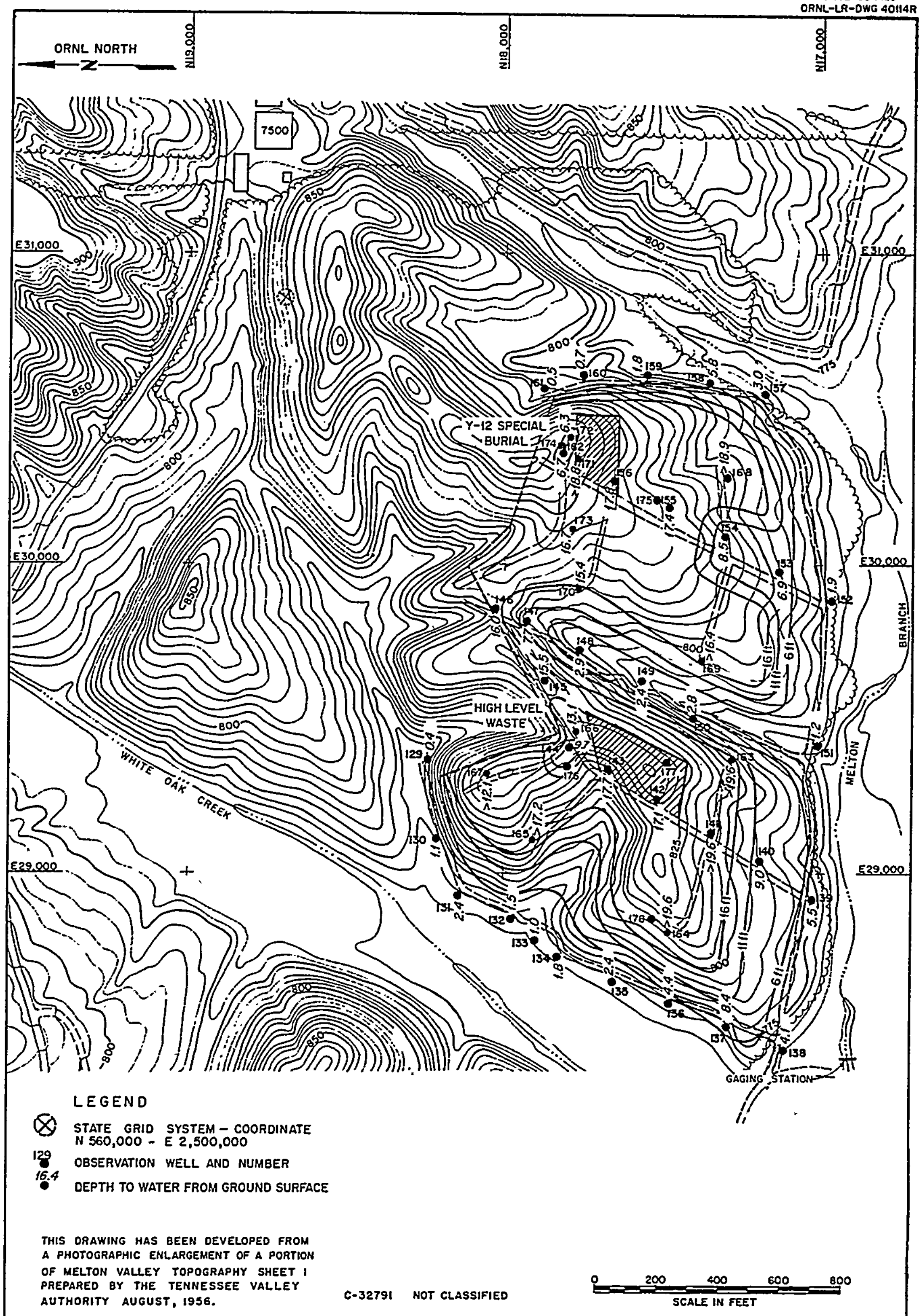

REV. I CONTOURS REVISED 8-15-58 REV 2 ADDED WELLS 163 THRU 173 AND ROADS. 11-3-58

Fig. 3. Minimum Depth-to-Water Contours.

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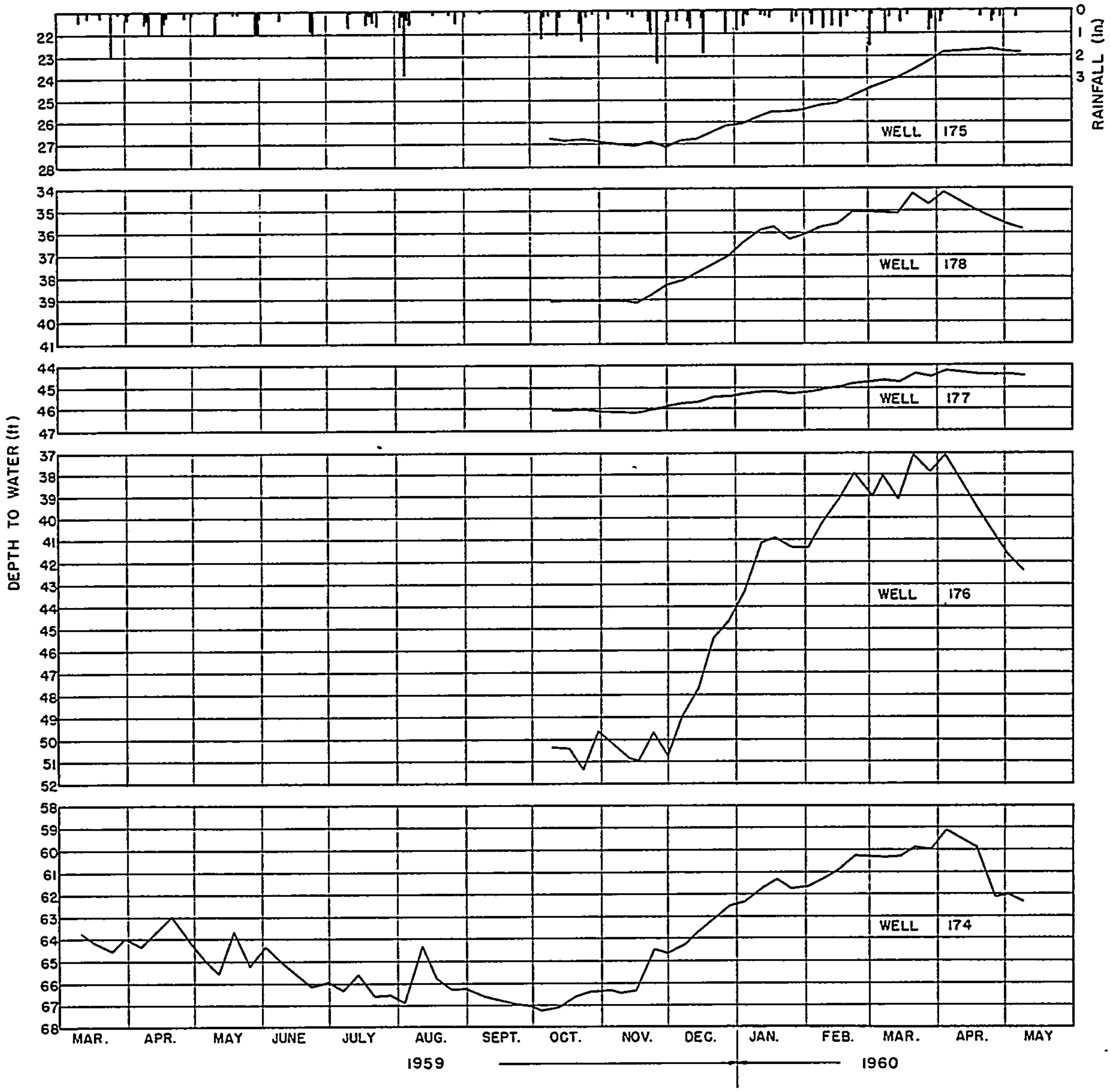

Fig. 4. Hydrographs for Deep Wells.

differences are not clear; topographic location of the wells, permeability of the rock in the immediate vicinity of the wells, and possibly the nearby perched water-table conditions (in the case of wells 174 and 176) all influence water-level fluctuations.

With water-level measurements from the deep wells, it was possible to construct a more complete water-table contour map than with auger-well measurements. Figure 5 shows the water-table configuration on December 3, 1959. In general, the water table is a suppressed replica of surface topography. Water flows from areas of high elevation to areas of low elevation, and, in general, the principal movement is in a direction normal to the contour lines. The path of water movement through the Conasauga shale has not been defined in detail, but it is known that ground-water flow is influenced by the strike of the formation. The closely-spaced contours in the eastern half of the burial ground, near wells 152 and 154, suggests a restriction to flow, or greater head loss. The steep gradient here lies normal to strike, a direction in which water movement is known to be retarded.

The circulation of water in depth was investigated by pressure testing churn wells 175, 176, 177, and 178. This method consists of expanding a rubber packer against the side wall of the well and pumping water under pressure into that portion of the well below the packer. Since the wells are cased down to fresh rock, the permeability of the weathered shale was not tested. From Fig. 6 it can be observed that the acceptance rates are, in general, greater near the top of the fresh shale. Thus, the most permeable zones or fractures occur within the frist 100 ft. Acceptance rates

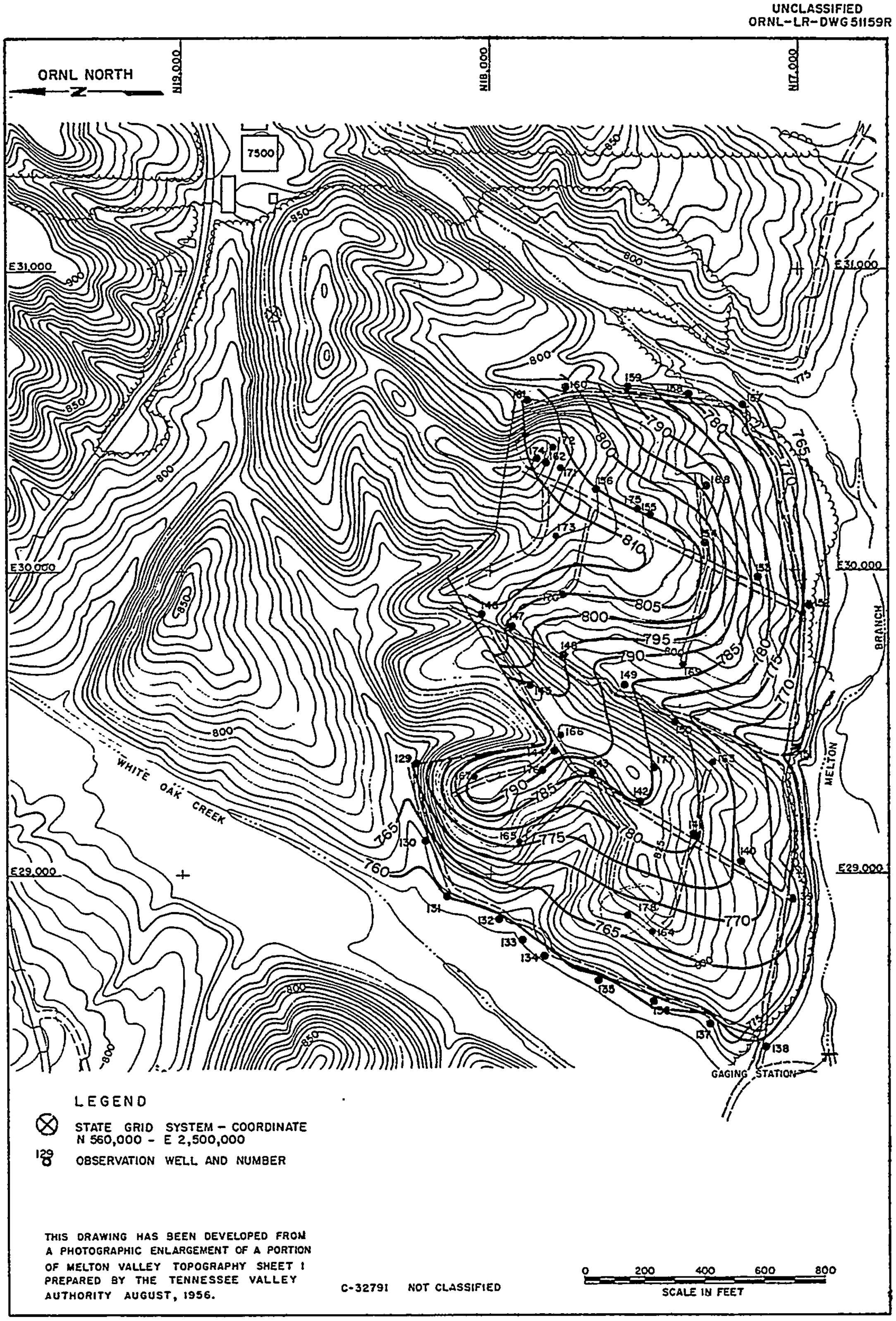

Fig. 5. Water-Table Contour Map, December 3, 1959.

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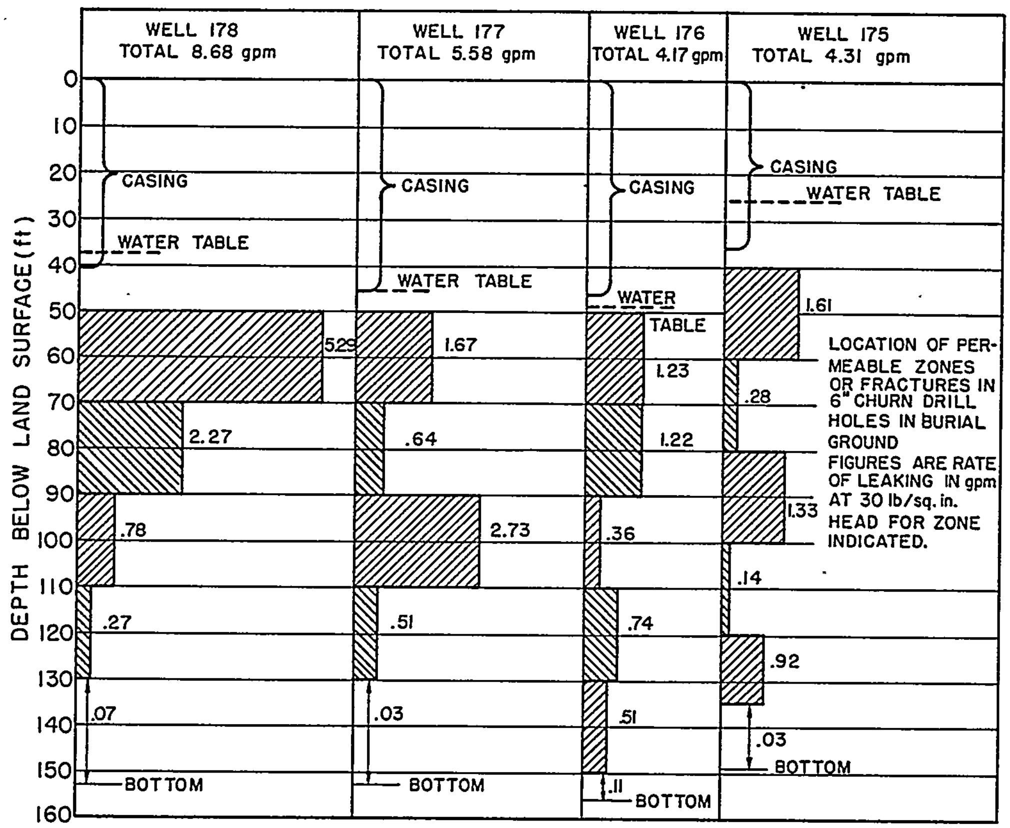

Fig. 6. Pressure Testing of Deep Wells.

vary from 5.29 gpm to 0.07 gpm. The wide range in acceptance rates of the different wells and at various depths within the wells show that the rock underlying the burial site is not homogeneous. Such inhomogeneity is not unexpected in the Conasauga shale.

Underground movement of water at the site of the ORNL waste-seepage pits, located approximately 1/2 mile along the strike southwest of the burial ground in the Conasauga shale, is very similar to that described here. The most permeable part of the shale underlying the pits is in the weathered portion and in the fresh shale near the top. Pumping tests and pit operation have shown that most ground-water movement is along the strike of the formation. Due to the inhomogeneity of the shale, the rate of ground-water flow varies throughout the pit area.

Table 1 lists the chemical analyses of water taken from a number of auger wells in the burial ground. The analyses indicate a calcium bicarbonate water of low-dissolved solids. Calcium and magnesium are the principal cations, and bicarbonate is the predominant anion. The values for the ratio of calcium to magnesium, expressed in equivalents per million, suggest that the water obtained calcium from limestone containing very little magnesium (see Table 2). Since the mechanism of bicarbonate formation renders the carbonates soluble, the high proportion of bicarbonate is to be expected. The shale fraction of the rock probably accounts for the sulfate ion concentration.[16]

These water samples were taken prior to burial operation in the area (during December 1958). Thus the analyses may be used for comparison with

Table 1. Chemical Analyses of Water from Auger Wells in Burial Ground 5
(parts per million)

Composite Sample No.	Date of Collection	Well No.	SiO_2	Al	Fe	Li	Mn	Sr	Ca	Cu	Mg	Zn	Na	B	K
1	Dec. 18, 1958	138,139,152,157	8.6	0.0	0.07	0.1	1.2	0.1	68	0.0	5.5	1.0	2.1	0.0	0.8
2	Dec. 17, 1958	132,133,134,135 137	8.4	0.1	0.00	0.2	0.22	0.1	89	0.0	12.0	0.5	3.9	0.0	1.1
3	Dec. 18, 1958	147,148,149,150	9.4	0.2	0.01	0.2	2.00	0.1	88	0.0	8.2	0.5	4.4	0.0	0.8
4	Jan. 15, 1959	158,159,160,161	8.3	0.0	0.45	0.2	0.22	0.1	82	0.0	8.4	0.5	3.5	0.0	0.8
5	Dec. 30, 1958	127,130	9.1	0.1	0.88	0.2	0.22	0.1	69	0.0	7.5	0.5	4.0	0.0	0.7

Composite Sample No.	Pb	Cr	CO_3	HCO_3	SO_4	Cl	F	NO_3	PO_4	Br	I	Dissolved Solids	Total Hardness as $CaCO_3$	Color	pH	Specific Conductance (micromhos at $25^{0}C$)
1	0.0	0.0	0.0	221	8.7	1.3	0.0	1.2	0.0	0.0	0.0	208	193*	5	7.5	353
2	0.0	0.0	0.0	263	55.0	1.9	0.2	2.1	0.0	0.0	0.0	305	272*	5	7.7	491
3	0.0	0.0	0.0	306	10.0	1.0	0.1	0.3	0.0	0.0	0.0	276	258*	10	7.7	472
4	0.0	0.0	0.0	256	27.0	1.8	0.2	1.4	0.0	0.0	---	263	239*	5	7.4	429
5	0.0	0.0	0.0	227	15.0	1.5	0.1	0.9	0.0	0.0	0.0	222	204*	5	7.1	378

*Includeds hardness of all polyvalent cations reported.

Table 2. Calcium-Magnesium Comparisons

Composite Sample No.	Calcium (epm*)	Magnesium (epm*)	Ratio Ca:Mg
1	3.4	.45	7.5
2	4.4	.99	4.4
3	4.4	.67	6.6
4	4.1	.69	5.9
5	3.4	.62	5.5

*Equivalent parts per million.

future samples to determine any change in the chemical content of the ground water brought about by leaching of the waste. The gross beta counting rate of all samples was not different from zero at the 5% level of significance.

The depth to ground water and the fluctuations in elevation of ground water are important considerations in the burial of solid waste. By burying the waste above the water table, leaching is eliminated or minimized, and possible movement of radionuclides away from the site is prevented or retarded. Since ground water is the primary media of transport, maps of the water table, coupled with information of the geologic structure, will aid in determining the direction of waste movement and the points of seepage to the surface. The rate of ground-water movement influence the reduction in concentration of radionuclides by ion exchange and by decay before the liquid reaches a surface water course.

Past Experience at ORNL

The waste buried at ORNL consists of a wide variety of contaminated items. Included are such things as depleted uranium, filters, inactive portions of fuel rods, kleenex, all types of glassware, blotting paper, lumber, dirt, miscellaneous equipment, and animal carcasses. Some of these materials are buried in metal, wood, plastic, or concrete containers, while others are simply dumped into the trenches.

Approximately 50% of the waste is produced at Oak Ridge, while the remainder is contributed by off-site agencies. Knolls Atomic Power Laboratory, Argonne National Laboratory, and the General Electric Company of Evendale, Ohio, are the principal off-site shippers.

Existing records give some indication as to the volume of waste buried, but information on the types and amounts of radioactive isotopes is generally lacking. Off-site shippers are requested to define the curie content of their waste, but this information is frequently incomplete or not reported, especially in the case of large shipment. The activity in curies associated with ORNL solid waste is also unknown.

In the past the burial procedure consisted of excavating trenches in the weathered shale, generally 12-14 ft deep, dumping the contaminated solids into the hole and then covering with soil. Until recently, trenches containing alpha waste were covered with concrete. Auger holes, 1 to 2 ft in diameter and about 15 ft deep, were used to dispose of extremely high-level waste. In addition, some high-level waste was buried in individual stainless steel containers (see Fig. 7). This method of operation was economical and convenient, and, to date, no serious hazards have developed as a result of the operation. However, a study of a recently abandoned burial ground, Burial Ground 4, showed that most of the buried waste was and is in continuous contact with ground water, and radionuclides were detected in the wells, seeps, and streams in the area. It is believed that soluble waste material is transported by ground water through the weathered soil to points of discharge in or near surface streams. A report on the results of this study will be presented later.

Future Considerations at ORNL

Little change is expected in the type of wastes to be buried in the near future. However, unless a Regional Burial Ground for the East Coast

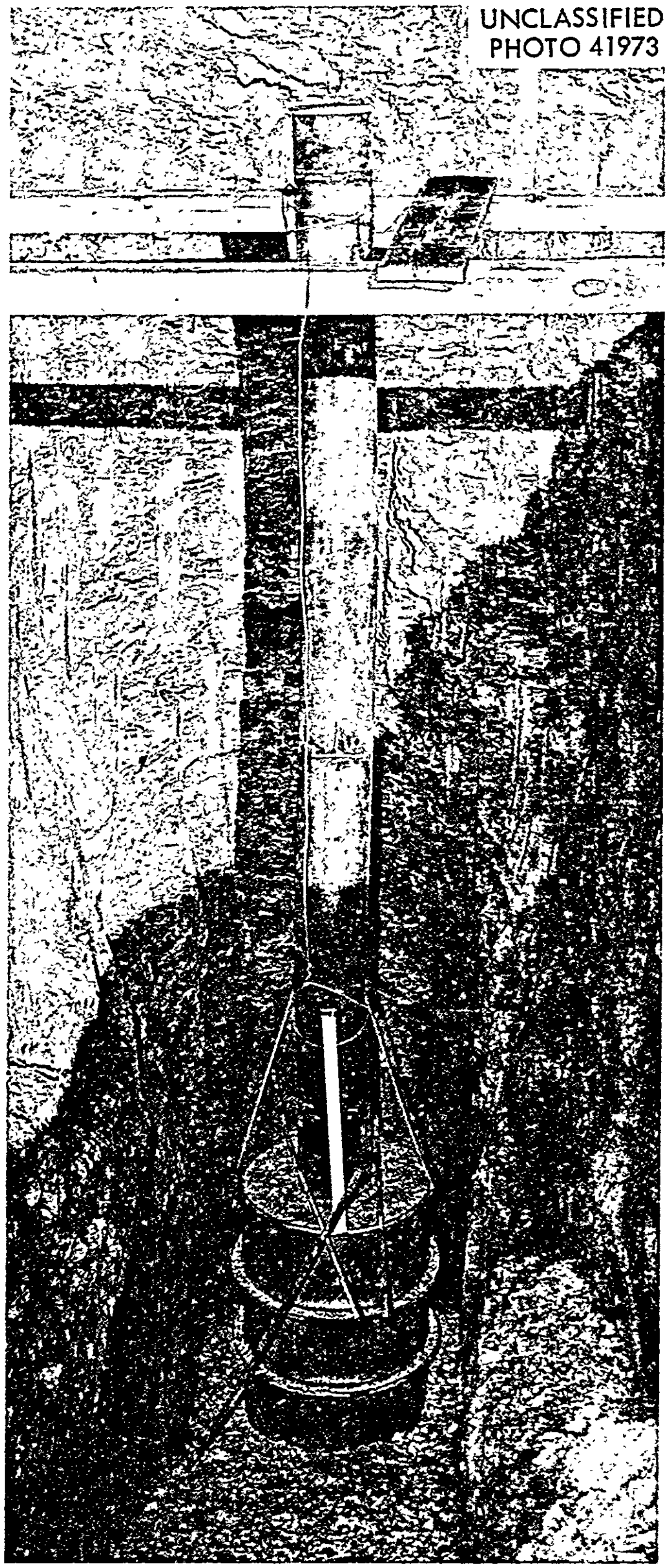

Fig. 7. Special High-Level Facility.

of the United States becomes operative, the volume of waste over the next few years is expected to increase. For most efficient use of the burial ground, a plan for future disposal operations is necessary.

To estimate the requirements of land usage, records of solid waste burial dating back to 1957 were analyzed. By linear extrapolation of these data, estimates of the volumes of waste expected through 1964 were made and are summarized in Table 3. Estimates of the volumes of alpha and beta-gamma wastes are included; namely, 1.1×10^6 cu ft of alpha-contaminated waste and 9×10^5 cu ft of beta-gamma-contaminated waste.

By use of the depth-to-water map, Fig. 3, the volume available for burial of solid waste can be determined. With the restriction that solid waste should be buried 1 ft above the highest water level, the depth of burial in the area between the 6- and 11-ft depth-to-water contours should be limited to 5 ft. Similarly, the depth of burial in the area between the 11- and 16-ft contours and above the 16-ft contour should be limited to 10 and 15 ft, respectively. A 15-ft-deep trench is the maximum depth possible due to the limitations of existing equipment. The volume available for disposal of solid waste in the outlined area is approximately 21×10^6 cu ft. The areas reserved for high-level waste and other special waste are not included in the calculations. Where the depth to water is less than 6 ft, such areas can be used for disposal of noncontaminated solids.

The total volume of a trench is not occupied by solid waste. A conservative estimate of the occupied volume is 50%. For convenience of operation a trench width of 10 ft is normally employed, and a 5-ft spacing between trenches assures the integrity of each trench and a reasonable

Table 3. Estimated Volumes of Solid Waste for 1960 Through 1964
In Thousand of Cubic Feet

Waste	1960	1961	1962	1963	1964	Total
Alpha	197	194	237	224	262	1114
Beta-Gamma	163	173	186	193	201	916
Total ------	360	367	423	417	463	2030

working area. Therefore, only two-thirds of the available area would be useable. With these limitations, about one-third of the total volume in the burial ground will be occupied by solid waste. Considering all restrictions, the area east of the road, along which wells 152 and 156 are located, provides about 1.4×10^6 cu ft of burial space; this should be ample for the alpha-contaminated waste expected through 1964. East of the road, along which wells 146 through 151 are located and west of the site for alpha-waste burial, about 2.2×10^6 cu ft is available for burial of beta-gamma-contaminated waste.

A special area of the burial ground has been set aside for high-level wastes (see Fig. 3). The site will be used primarily for the burial of waste salts from the Volatility Pilot Plant Operations at ORNL, but it is large enough (1.3 acres) to accommodate other extremely high-level wastes. The hydrologic conditions that exist at this site makes it a preferred area for disposal of high-level solids in the burial ground.

To simplify and improve monitoring, a new trench design is recommended. Such a trench was employed for the disposal of a particular shipment of solid waste from the Y-12 installation at Oak Ridge (see Fig. 8). The bottom of the trench, covered with 6 in. of gravel, was sloped to an asphalt-lined sump at one end in which a 6-in. perforated casing was installed. Any liquid entering the trench will flow primarily through the gravel underdrain to the collecting sump, from which samples can be withdrawn and analyzed. After the trench was filled with waste, the void space around the contaminated material was backfilled with shale. A layer of shale near the top of the trench was compacted by tamping, providing a base for an asphalt cap as

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Fig. 8. Gravel Underdrain System and Collecting Sump for Y-12 Waste.

shown in Fig. 9. About 1 in. of asphalt was sprayed on a gravel base; and after the asphalt hardened, the remainder of the opening was backfilled with shale. The composition and amount of liquid collected in the sump is being used to evaluate the extent of leaching of radioactive materials from the waste and will serve as an indicator of the effectiveness of the asphalt cap in diverting rainfall. In addition, the perforated casing extending above the ground surface serves as a permanent marker for the trench.

To date, two trenches have been completed. The waste in both is contained in metal drums and consists mostly of alpha-contaminated material. Water has been observed in the sumps only after heavy rainfall and extended wet periods. It is believed that the water is seeping in from the unlined side walls since the trenches are situated above the water table and the asphalt cover should prevent direct overhead percolation. Samples taken from the sumps and analyzed show gross alpha activity as high as 12.08 ± 0.75 c/m/ml and gross beta activity of 3.02 ± 0.65 c/m/ml. In order to determine the importance of container integrity to ground-water leaching, the drums in Trench 1 were placed in an upright position (see Fig. 10), while those in Trench 2 were dumped at random (see Fig. 11). To date, monitoring data indicate that damage to the container incurred in dumping does not cause an increase in the activity leached from the waste. However, the material has been buried only since February 1959, making it impossible at this time to evaluate long-range effects.

The amount of water that collects in the sump of Trench 2 is greater than that observed in the sump of Trench 1. This is probably due to the

Fig. 9. Asphalt Cap Over Backfilled Trench for Y-12 Waste.

Fig. 10. Waste Placement in Y-12 Trench 1.

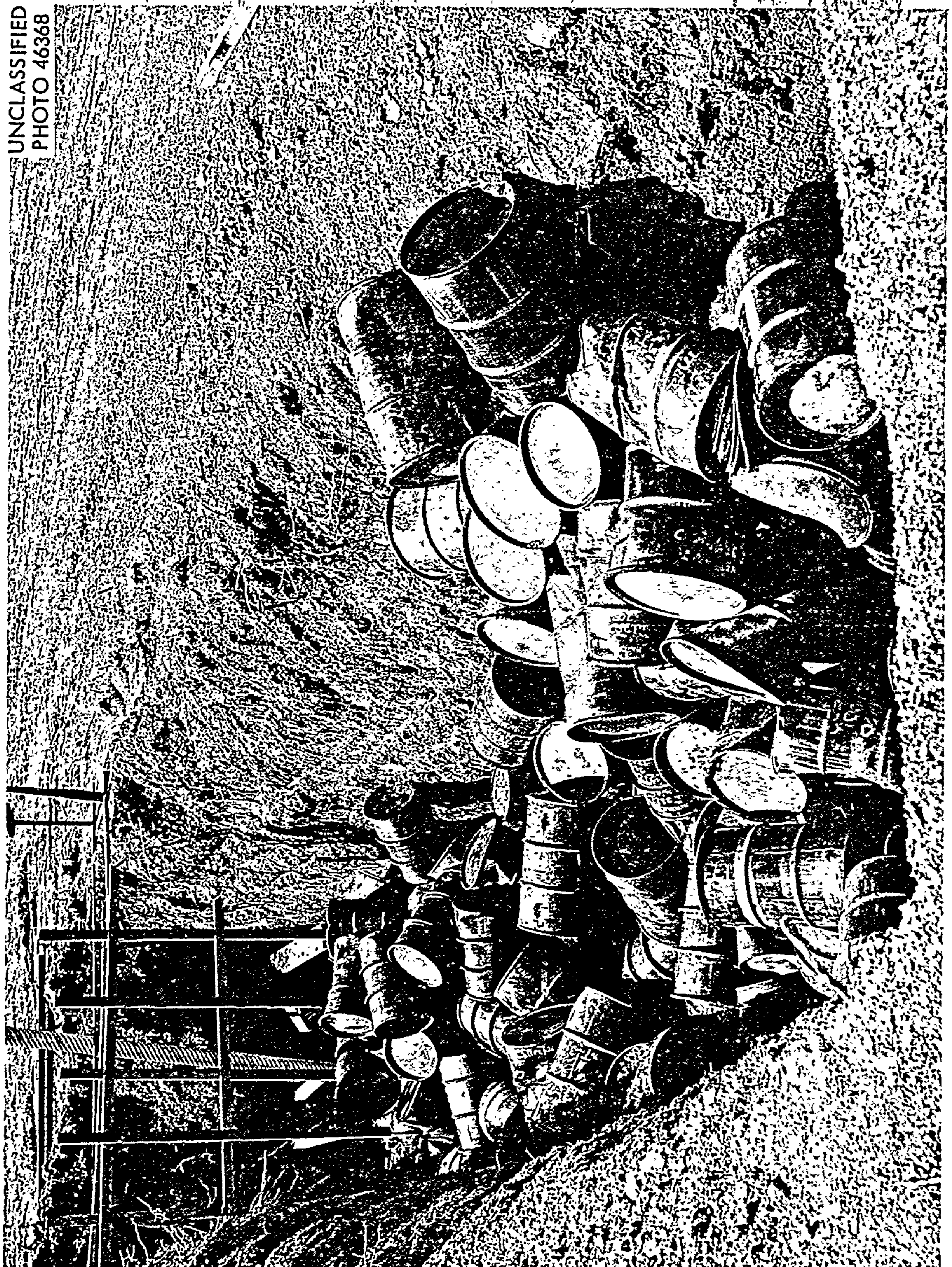

Fig. 11. Waste Dumped in Y-12 Trench 2.

influence of the open trench adjacent to Trench 2. Rainfall accumulates in the trench (see Fig. 12), and, due to the low permeability of the underlying shale, seepage is slow. Since the trenches lie at right angles to strike, it is reasonable to conclude that some seepage is in the direction of Trench 2. This situation allows the waste in Trench 2 to be subjected to additional and undesirable leaching.

The total cost incurred for disposal in Trench 1 was $1,000. This included $200 for excavation and filling, $200 for the construction of the sump, well, gravel underdrain, and asphalt cover, and $600 for placement of waste containers in the trench. The excavation and filling expense did not add to operating cost, since this would have to be done in any trench disposal. The trench was about 70 ft long, 10 ft wide, and 12 ft deep, comprising a volume of 8,300 ft^3. Thus, the additional cost of the sump, well, gravel underdrain, and asphalt cover was about $0.02 per ft^3 of trench space. The cost of individual drum placements in the trench was $0.07 per ft^3 of trench space. Should the trenches be larger than the one described above, the cost per cubic foot for the monitoring system would be less.

Some ecological work is carried on in the burial ground, and additional studies are planned for the future. Prior to waste burial, samples of the vegetation in the area are collected and analyzed. In some areas, trees have been left to study the possible uptake of radionuclides.[17]

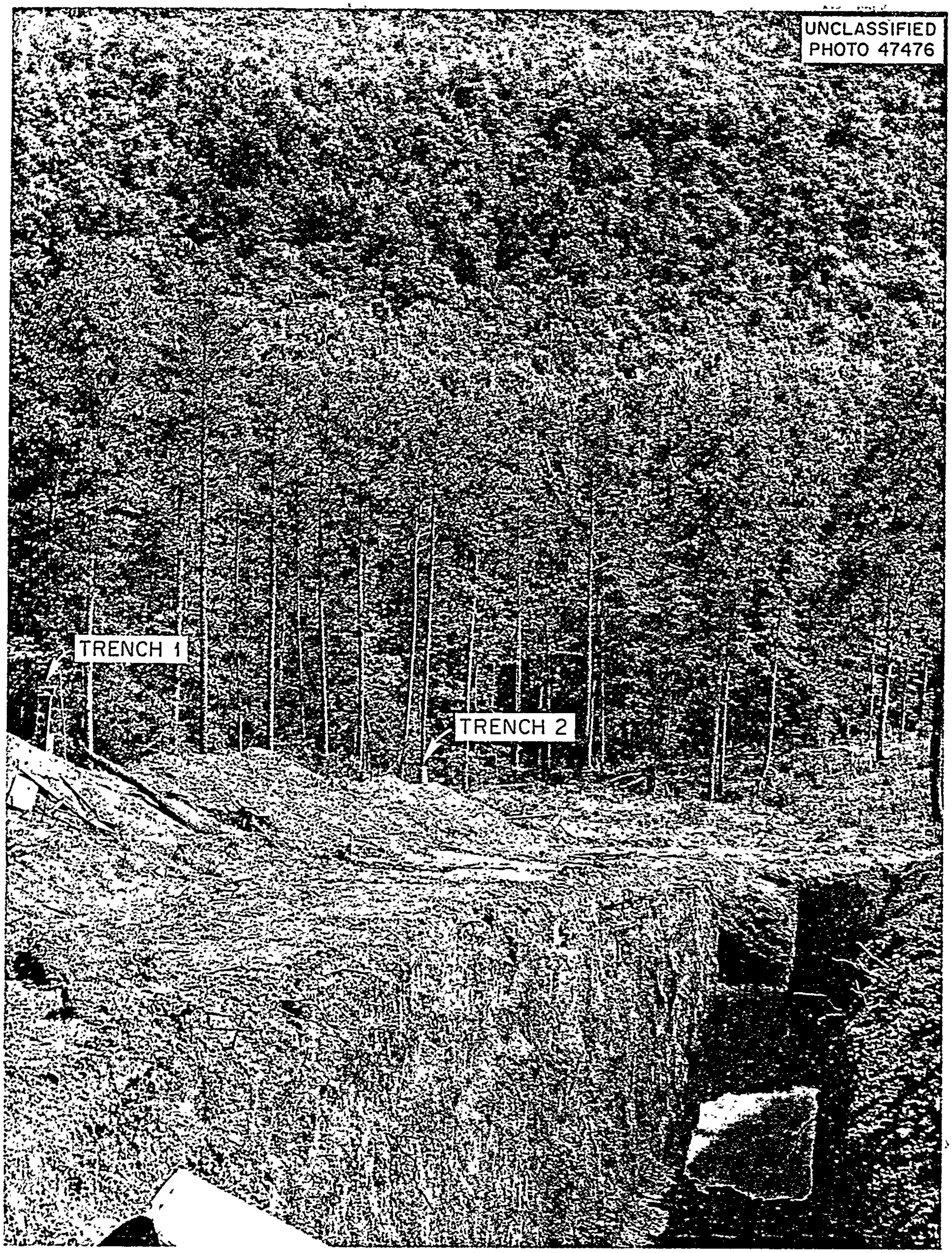

Fig. 12. Standing Water in Open Trench Adjacent to Y-12 Waste Trench 2.

Conclusions and Recommendations

It is advisable to set aside special areas within the burial ground for specific waste types. In addition to providing better control and operation, this procedure would place the most active and presumably the most hazardous waste in a preferred site within the burial ground.

Present burial ground records are inadequate. As a result, routine burial operations, long-range planning of burial ground expansion, fulfilling requests for information by local and outside authorized groups, and evaluation of burial procedures and underground movement of waste materials are difficult if not impossible. A map showing the exact location of each trench and more complete information concerning the volume, type, and activity of waste will largely resolve these difficulties.

In order for radionuclides to move from the trenches, through the soil, and into surface streams, it is necessary that water come in contact with the waste. This can occur by downward percolation of rainfall or by intersection of a trench with the ground-water table. It is not possible to prevent all rain that falls in the burial ground from coming in contact with the waste even though the trench may have an asphalt cover However, it can be substantially reduced. By suspending the waste above the ground water table, leaching can be prevented or minimized. Radionuclides have been detected in water samples from wells, seeps, and streams in Burial Ground 4, recently abandoned, where ground water is in continuous contact with the buried waste. The use of a depth-to-water map will aid in the design and location of trenches above the water table.

The recommended trench design will greatly simplify and improve monitoring. In addition, the perforated casing can serve as a permanent marker for the trench. The additional cost of the sump, gravel underdrain, and asphalt cover is small at $0.024 per cu ft of trench space. The stacking of waste containers in the trench does not seem to be justified at this time. In addition to the higher cost of this operation, results to date show that the amount of activity leached from drums dumped into the trench is not greater than when the drums are carefully placed in a trench.

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